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Off-farm Investment in Financial Assets as a Risk Response for New Zealand Sheep and Beef Farms

Gilbert V. Nartea and Juan M. Pellegrino*

Abstract

Off-farm investment as a risk management strategy is not particularly popular among New Zealand sheep and beef farmers. This study explores the potential reduction in risk by diversifying farm asset portfolios to include financial investments. Portfolio analysis revealed that the negative correlation between rates of return on farm assets and shares found in the study could result in a risk reduction of as much as 20% by converting 16 to 25% of the farm investment portfolio into shares. These findings indicate that off-farm investment could be an important risk response for farmers.

Key words: *Risk management, diversification, portfolio theory, off-farm investment.*

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Introduction

A recent survey of farmers and growers in New Zealand (NZ) revealed that their preferred risk management strategies have a predominantly on-farm focus (Martin, 1996). The survey showed that in order to stabilise their returns, farmers and growers rely mostly on precautionary measures such as spraying and drenching, farm enterprise diversification, and keeping debt levels at a low level. Off-farm financial strategies for reducing risk, such as off-farm investment are not favoured by any group, perhaps because these are not perceived as particularly efficient strategies for managing risk (Martin, 1996). There might be a large gap between farmer perceptions and the reality with off-farm diversification. In a US study, Young and Barry (1987) showed for Illinois grain farms that investment in financial assets could reduce the relative variability of a farm's rate of return on assets by 15% to 25% compared to holding farm assets alone. In New Zealand, appropriate comparisons of on-farm and off-farm investment incorporating risk criteria are not well developed (Johnson, 1992). Apart from a paper by Narayan and Johnson (1992) using the capital asset pricing model to suggest the desirability of off-farm versus on-farm diversification, no other significant studies have been done in this area. Accordingly, this paper uses portfolio theory to investigate the importance of off-farm investments as a risk response for NZ sheep and beef farmers. Specifically, the paper quantifies risk-reduction benefits of moving from farm assets alone to an investment portfolio of farm and shares.

Portfolio Theory

Portfolio theory as developed by Markowitz (1952) and later extended by Sharpe (1964) and Lintner (1965) assumes that the choice of optimal asset combinations or portfolios depends mainly on the mean and variance of the asset's returns.

In portfolio theory, risk is measured by the variability of returns. A combination of several assets usually has a lower risk (total variability of returns) than any one of the assets making up the asset mix. The degree of risk reduction from combining assets into a portfolio depends on the statistical relationship among the returns of the asset mix. Diversification becomes more effective in reducing risk as the covariation of returns among the assets falls. To illustrate, take the case of two assets, A_1 and A_2 , combined in an equally weighted portfolio. The expected return, $E(r_p)$ and standard deviation, σ_p of this portfolio can be expressed by the following equations,

$$(1) \quad E(r_p) = x E(r_1) + (1-x) E(r_2)$$

$$(2) \quad \sigma_p = [x^2 \sigma_1^2 + (1-x)^2 \sigma_2^2 + 2 x (1-x) \Psi \sigma_1 \sigma_2]^{0.5}$$

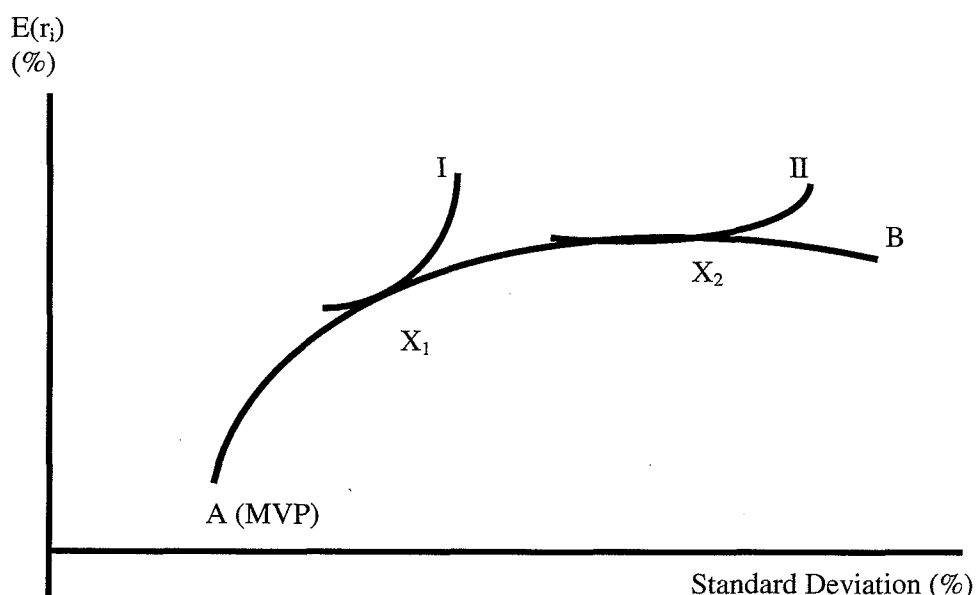
where $E(r_1)$ and $E(r_2)$ are the expected rates of return of A_1 and A_2 , σ_1 and σ_2 are their respective standard deviations, Ψ is the correlation between the rates of return of A_1 and A_2 , and x and $(1-x)$ are the respective proportions of A_1 and A_2 in the portfolio. Let A_1 and A_2 have identical expected rates of return of 10%, and identical standard deviations (σ_1 and σ_2) of 15%. Further, let the correlation coefficient between the rates of return on A_1 and A_2 equal 0.3. Substituting these numbers in (1) and (2) above shows that an equally weighted portfolio of the two assets will only have a standard deviation (σ_p) of 12% compared with

15% without diversification. Using the coefficient of variation (C.V.) as a measure of relative risk, indicates that this is equivalent to a 20% risk reduction, i.e., the C.V. with diversification is 1.2 compared with 1.5 without diversification. This is the definition used when referring to risk reduction. That is, the term “percentage risk reduction” will refer to the percentage change in the coefficient of variation when moving from one portfolio to another.

It is also apparent from equation (2) that there would be no risk reduction if the rate of return on the assets is perfectly positively correlated ($\Psi = +1$). However, increased risk-reduction occurs as the correlation coefficient moves away from 1, reaching a maximum when the rates of return are perfectly negatively correlated ($\Psi = -1$). These relationships are generalised for a portfolio of n assets in the appendix.

Given any number of assets, one can form portfolios which are risk-efficient. A risk-efficient portfolio is defined as a combination of assets which maximises the expected returns for a given level of risk (measured as variance or standard deviation), or one that minimises the risk level for a desired expected rate of return. The risk-efficient portfolios could be plotted in mean-standard deviation space as a combination curve such as AB in Figure 1, with each point on the curve defining a specific combination of assets. The portfolio with the lowest risk is called the minimum variance portfolio or MVP. As we move up the combination curve, we define portfolios with higher rates of return but also higher levels of risk. Portfolio theory states that investors will choose from among these portfolios according to their risk attitudes. Curves I and II represent the indifference curves of two hypothetical risk-averse investors. The curves are convex down and rise from left to right indicating that additional increments of standard deviation (risk) require increasingly larger increments of expected return. The individual with indifference curve I has his/her optimal portfolio at point X_1 . A less risk-averse individual represented by indifference curve II will have his/her optimal portfolio at point X_2 .

FIGURE 1
Risk Efficient Set



The risk-efficient portfolios could be generated by solving the following quadratic formulation:

$$(3) \quad \text{Min } \sigma_p = (\sum \sum x_i \sigma_{ij} x_j)^{0.5}$$

subject to

$$(4) \quad \sum x_i E(r_i) \geq Z$$

$$(5) \quad \sum x_i = 1$$

where σ_p is the portfolio standard deviation, x_i is the proportion of asset i in the portfolio, $E(r_i)$ is the expected return of asset i , σ_{ij} is the covariance between assets i and j (variance of asset i if $i=j$), and Z is the required rate of return which is varied parametrically to obtain the risk-efficient set.

Data

Measures of risk and expected returns were based on a time series of annual rates of return for farmland and shares for the period spanning 1966 to 1996. The annual rates of return were composed of two parts, the current return and the capital gain expressed as (Sharpe, 1978; Levy and Sarnat, 1984)

$$(6) \quad R_{it} = D_{it} + (A_{i1} - A_{i0}) / A_{i0}$$

where R_{it} is the total rate of return in year t for the i th asset, D_{it} is the current return, A_{i0} is the asset value at the beginning of each year, and A_{i1} is the asset value at the end of the year. The capital gain component represented both realised and unrealised capital gain. The rationale for including unrealised capital gain in the computation of the total rate of return is that the decision of holding on to the asset at the end of the year, thereby not realising the capital gain, is no different from “selling” it at year end, “realising” the capital gain, and immediately reinvesting by buying the asset back (Ross, Westerfield, and Jordan, 1991).

The return on shares used in this study did not include the current return component, i.e., dividends. The impact of this omission will be addressed later when the results are discussed. Shares were represented by the New Zealand Stock Exchange (NZSE) 40 Capital Index. Prior to 1991, the index was called the Barclay's Index. The NZSE took over the computation of the index in 1991 coinciding with the listing of Telecom. The NZSE 40 Capital Index covers 40 of the largest and most liquid shares weighted according to their market capitalisation. The capital index however, measures only the capital value of the securities excluding dividends. The capital index thus reflects the rise in share prices when a security is quoted *cum dividend* and the fall when it is quoted *ex dividend*.¹ Share rates of return were represented by the year to year percentage change in the reported value of the share price index thereby representing only the capital gain component of the total return on shares. An index such as the NZSE 40 Gross Index, which is adjusted for dividends, would be the better measure. However, this index only goes as far back as 1987.

Farmland referred to sheep and beef grazing farmland. The yearly total farmland rate of return was the sum of the production rate of return and the capital gain. The production rate

of return was the weighted average rate of return on assets for all classes of sheep and beef farms as reported in the New Zealand Sheep and Beef Farm Survey (NZMWBES). The NZMWBES classifies all sheep and beef farms in New Zealand into eight classes. A sheep and beef farm is defined in the NZMWBES survey as a privately operated farm which winters at least 750 sheep or their equivalent stock units in terms of sheep and cattle stock. At least 80% of the stock units on the property must be sheep and/or beef cattle stock and at least 70% of the farm revenue is derived from sheep or beef cattle.

The production rate of return was the economic farm surplus (EFS) divided by total farm capital. The EFS was the net income before interest, rent, and taxes, less an imputed managerial reward (NZMWBES, 1996). The managerial reward had two components -- a labour component and a managerial component. The labour component was assumed to be the equivalent ruling wage for an experienced farm worker adjusted for the number of working owners on the property. The managerial component was imputed at 1 per cent of farm capital. Total farm capital was defined as farm assets at market value plus an allowance for working capital (NZMWBES, 1996). The working capital allowance was assumed to be 50% of the sum of working expenses and imputed managerial reward.

The capital gain component was the percentage change in a grazing land price index. This was considered a proxy for capital gain on farm assets since it does not include capital gains (or losses) on depreciable assets. This index was obtained from Valuation New Zealand. This price index related prices paid for properties to the relevant government valuation thereby tracking a price/value ratio. Ideally, a pure price index would have been preferred. However, given that the land market is relatively thin, there could be some merit in Valuation New Zealand's incorporation of its own valuation into this "price index".²

Results

Table 1 shows the mean, standard deviation, and coefficient of variation of the annual rates of return on farmland and shares. The data reveals that farmland has outperformed the share market in terms of mean rate of return over the study period, though one should note that the returns to shares reported here exclude dividends. Shares were also clearly more risky. Share rates of return were nearly three times more volatile than farmland rates of return. We should note however, that farm rates of return were based on averages of various cost and return items for the individual farms included in the New Zealand Sheep and Beef Farm Survey (NZMWBES). This understates the degree of variability of individual farms. Furthermore, farmland investments are relatively illiquid compared with shares. This characteristic of the assets was not accounted for in the analysis, hence further understating the risk in farmland investments relative to that of financial assets.

TABLE 1

Risk and Return Measures for Farmland and Shares, 1966-1996^a

	Mean rate of return	Standard deviation	Coefficient of variation
	(%)	(%)	(%)
Farmland:			
Production return	3.61	1.61	45
Capital gain	12.31	14.88	121
Total rate of return	15.92	15.14	95
Shares ^b	12.19	33.50	275

^aAll figures are in nominal terms.

^bExcludes dividends.

A large part of the average rate of return, and also much of the volatility in farmland rates of return, were due to the capital gain component. The coefficient of variation of the capital gain component (C.V. = 121%) was nearly three times more variable than the production return (C.V. = 45%) (Table 1). Over the study period, the capital gain component accounted for 77% of total return. Capital gain averaged 12.31% over the study period while production returns averaged 3.61% (Table 1). This apparent disparity between capital gain and productive value of farmland is also evident in U.S. studies and has been the topic of numerous papers attempting to explain it. One possible explanation is the capitalisation into land values of various government tax policies and income and price support programs (Hendric, 1962; Tweeten and Martin, 1966; Chryst, 1968; Harris, 1977) and expectations of rapid increases in annual net returns (Schofield, 1964; Klinefelter, 1973; Chavas and Shumway, 1982). Another explanation is that rural land is not only an input of agricultural production but is also an argument in many individuals' utility functions, effectively creating a consumptive demand for rural land (Pope, 1985). Rural land therefore provides utility to individuals not only through its productive value but also, for example, through its aesthetic value which then gets capitalised in rural land prices. No definitive studies have been done in this area in the New Zealand context.

Over the study period, farmland rates of return and share rates of return were negatively correlated. With a correlation coefficient of -.38, substantial risk reduction could potentially be gained by combining these two assets in an investment portfolio. The risk reduction benefits were quantified using portfolio analysis. Table 2 shows the risk-efficient investment portfolios obtained by solving equation (3) subject to (4) and (5) for alternative values of Z . The quadratic formulation was solved using INVEST Version 1.01 which is a supplementary software accompanying Haugen R. (1990). Table 2 also shows the mean rate of return, standard deviation, and coefficient of variation of each portfolio, as well as the percentage reduction in risk that is obtained by holding a portfolio of shares and farm assets compared with an investment only in a sheep and beef farm. Risk as defined was the coefficient of variation of a portfolio. The percentage reduction in risk referred to the percentage change in the coefficient of variation of a portfolio consisting of the farm and shares, relative to that of the sheep and beef farm alone. To illustrate, an investment consisting solely of the sheep and

beef farm (Portfolio 10) has a coefficient of variation of 95%. An alternative portfolio (Portfolio 6) consisting of 89% in a sheep and beef farm and 11% in shares has a coefficient of variation of only 81%. Therefore, investing in the alternative portfolio reduces risk by 17%.

Compared with holding sheep and beef farm assets alone, the risk-efficient portfolios showed reductions in risk ranging from 4 to 21% (Table 2). The level of farm assets in the risk-efficient portfolios ranged from 76 to 100 %.

At the lower end of the risk-efficient set is the minimum variance portfolio (MVP) which has a mean rate of return of 15% and a standard deviation of 11.3% (Table 2). As we move up the risk-efficient set, we can identify portfolios with higher rates of return but with correspondingly higher risks. Risk-efficient portfolios with higher rates of return are obtained by increasing the proportion of farmland and reducing shares in the mix.

The highest rate of return can be obtained by holding only the asset with the highest return. In this case, it is obtained by holding only farmland. By definition, this "portfolio" also has the highest level of risk.

The composition of the risk efficient set is obviously sensitive to the choice of the time period used in computing means, variances, and correlation coefficients of the rates of return. However, we do not expect the choice of the time period to significantly alter the basic conclusion of the study, i.e., combining financial assets with agricultural assets will result in risk reduction benefits. For instance, data for the twelve year period from 1985 to 1996 also revealed a negative correlation between farmland and share rates of return (correlation coefficient = -.41). The data also showed that a 20% reduction in risk can be obtained by converting 11% to 15% of the farm portfolio into financial assets. These numbers are very similar to those reported in Table 2.

Likewise for two reasons, we do not expect the omission of dividends from the analysis to significantly alter the results reported here. First, including dividends in the computation of the rate of return on shares, for example by using the NZSE 40 Gross Index instead of the NZSE 40 Capital Index, would obviously increase the mean rate of return on shares. *Ceteris paribus*, this would lead to a greater proportion of shares in the risk efficient set. Second, an analysis of data from 1987-1996 showed that the total rate of return on shares (i.e., including dividends) has a lower variability than just the capital gain component. Again, this suggests that had we used the total rate of return, the risk-efficient portfolios would contain even a greater proportion of shares, in line with the basic conclusion of this study.

At least three limitations in the analysis need to be cited at this stage. First, the analysis ignores transactions costs involved in portfolio restructuring. This omission overstates the benefits from diversification. Second, the assumption of constant economies of size is implicit in the analysis. If size economies are actually important, the rates of return on farm assets used here would be overstated as one diversifies into financial assets and away from agricultural assets. This in turn overstates the benefits from diversification. Third, the analysis uses historical data to determine measures of risk and expected rates of return implicitly assuming that the probability distribution of returns in the immediate future will be the same as that in the past.

TABLE 2
Risk-efficient Portfolios

	Portfolio									
	1 ^a	2	3	4	5	6	7	8	9	10
Composition (%)										
Shares	24.3	21.6	18.9	16.2	13.5	10.8	8.1	5.4	2.7	
Farmland	75.7	78.4	81.1	83.8	86.5	89.2	91.9	94.6	97.3	100
Expected return (%)	15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9
Standard deviation (%)	11.3	11.3	11.5	11.8	12.1	12.6	13.1	13.7	14.4	15.1
Coeff. of variation (%)	75	75	75	77	79	81	84	87	91	95
Risk reduction (%) ^b	21	21	21	19	17	17	13	9	4	

^aMinimum variance portfolio.

^bRefers to the percentage change in the coefficient of variation of any given portfolio relative to that of the portfolio consisting only of the sheep and beef farm (Portfolio 10).

Finally, there is the practical question of how one goes about restructuring the farm portfolio. This is by no means a trivial task given that farm real estate is generally considered a relatively illiquid asset caused by high transactions costs, tax obligations, indivisibilities, and thin markets. However, to our mind there are several avenues that might be worth pursuing. For one, farmers might consider selling off the extra farmhouse if they have one. Anecdotal evidence in New Zealand suggests that farmers have actually done this in the past in response to the low commodity prices in recent years. Another avenue might be to sell land that is suitable for conversion into lifestyle blocks. This might consist of farmland near roads, land at the margin of their properties, or land that is marginal in terms of productivity. Finally, farmers might actively pursue leasing arrangements both for farmland as well as equipment thereby lowering their actual investment in the farm. There is also the question of how often one should review the portfolio. As a practical matter we feel that the proportion of financial assets in the portfolio relative to agricultural assets could be kept fixed over a period of 5 to 10 years. We do not expect the fundamental relationship between these two types of assets to change within that time frame in the course of normal events. What could be adjusted more frequently is the composition of the financial assets making up the portfolio. This could be done at least once a year or even more frequently if the farmer is so inclined.

Conclusion

This study explored the potential reduction in risk from combining financial investments with farm assets. The analysis used historical data to estimate risk and expected returns for shares and farmland. The results have shown that for recent past data, such combinations can lead to more stable rates of return. The negative correlation between farm assets and shares found in this study indicate that significant risk reduction benefits could be obtained. Portfolio analysis revealed that a risk reduction of around 20% could be attained by converting 16 to 25% of the farm portfolio into shares. These findings indicate that off-farm investment in financial assets warrants greater attention than it has so far been accorded by farmers as a risk management strategy.

Notes

1. The index actually captures some of the dividends to the extent that at the time the index is computed, some shares are quoted *cum dividend*.
2. Given a relatively thin land market, using a pure price index such as one based on the yearly average sale prices can lead to an incorrect representation of the true situation. The difference in the mixes of properties sold between different periods will likely have a strong influence on the pure price index reported.

For example, let us assume that there is a general increase in land prices for all properties this year compared with last year. However, if the properties sold last year were inherently high value properties while the properties sold this year were inherently low value properties a lower average sale price will be reported this year compared with last year which leads to the incorrect conclusion that land prices decreased this year.

The index used by Valuation New Zealand excludes the effect of the difference in the mix of properties sold from year to year by relating the market prices with the relevant government valuation of the properties sold for any given year. The index is computed as:

Current Index = Previous Index x (Current Average Price Value Ratio/Previous Average Price Value Ratio)

The price value ratio above is the ratio of the market price of a property that was sold in a given year and its relevant government valuation.

To see how the index is unaffected by the mix of properties sold from year to year consider the following example. Assume that on average, properties were sold last year at 15% over their government valuation (i.e., price value ratio of 1.15), regardless of whether they are high value or low value properties, while properties were sold this year at 33% over their government valuation (i.e., price value ratio of 1.33), this indicates that prices have increased this year relative to last year. Assuming an index value of 1000 last year, based on the formula above, the current index would be

$$\text{Current Index} = 1000 \times (1.33/1.15) = 1156$$

This means that this year's prices increased by 15.6% [i.e., $(1156 - 1000)/1000$] over last year's prices.

While this price index effectively excludes the effect of the difference in the mix of properties sold from year to year, it has a drawback. The index rests on the assumption that the properties included in its calculation were all valued at the same point in time. To the extent that this assumption is not met, the reported index is biased. If the mix of properties sold this year were predominantly revalued upwards relative to the mix of properties sold last year, this would understate (overstate) any price increase (decrease) this year. In the same manner, if the mix of properties sold this year were predominantly revalued downwards relative to the mix of properties sold last year, this would understate (overstate) any price decrease (increase) this year.

References

- Chavas, J. and C.R. Shumway (1982). *A pooled time-series cross-section analysis of land prices*. Western Journal of Agricultural Economics, Vol. 7, 31-41.
- Chryst, W.E. (1968). *Land values and agricultural income: a paradox?* Journal of Farm Economics, Vol. 47, 1265-73.
- Harris, D.G. (1977). *Inflation-indices, price supports, and land values*. American Journal of Agricultural Economics, Vol. 59, 489-95.
- Haugen, R. (1990). *Modern Investment Theory, 2nd Edition*. Prentice-Hall Inc., New Jersey.
- Hendric, J.L. (1962). *The effects of the price support program for peanuts on the sale value of farms*. Journal of Farm Economics, Vol. 44, 1749-53.
- Johnson, R.W.M. (1992). *Risk and the farm firm: a corporate finance view*. Review of Marketing and Agricultural Economics, Vol. 60, 9-21.
- Klinefelter, D.A. (1973). *Factors affecting farmland values in Illinois*. Illinois Agricultural Economics, Vol. 13, 27-33.
- Levy, H. and M. Sarnat (1984), *Portfolio selection: Theory and practice*. Prentice-Hall, New Jersey.
- Lintner, J. (1965). *The valuation of risky assets and selection of risk investments in stock portfolios and capital budgets*. Review of Economic Statistics, Vol. 47, 13-37.
- Markowitz, H.M. (1952). *Portfolio selection*. Journal of Finance, Vol. 12, 77-91.
- Martin, S. (1996). *Risk management strategies in New Zealand agriculture and horticulture*. Review of Marketing and Agricultural Economics, Vol. 64, 31-44.
- Narayan, P., and R.W.M. Johnson (1992). *Diversifying risk on New Zealand sheep and beef farms*. MAF Policy Conference Papers in Agricultural Economics 1992, Wellington, 105-114.
- New Zealand Meat and Wool Board's Economic Service, *The New Zealand Sheep and Beef Farm Survey*, Wellington. Selected issues.
- Pope III, CA. (1985). *Agricultural productive and consumptive use components of rural land values in Texas*. American Journal of Agricultural Economics, Vol. 67, 82-86.
- Reserve Bank of New Zealand. *Reserve Bank Bulletin*, Wellington. Selected issues.
- Ross, S.A., R.W. Westerfield, and B.D. Jordan (1991). *Fundamentals of Corporate Finance*. Irwin, Boston.

- Schofield, W.H. (1964). *Land prices and farm income relationships*. Agricultural Finance Review, Vol. 25, 13-22.
- Sharpe, W.F. (1964). *Capital asset prices: a theory of market equilibrium under conditions of risk*. Journal of Finance, Vol. 9, 425-42.
- Sharpe, W.F. (1978). *Investments*, Prentice-Hall, New Jersey.
- Tweeten, L.G., and J.E. Martin (1966). *A methodology for predicting U.S. farm real estate price variation*. Journal of Farm Economics, Vol. 48, 378-93.
- Valuation New Zealand. *Rural Property Sales Statistics*. Wellington. Selected issues.
- Young, R. and P.J. Barry (1987). *Holding financial assets as a risk response: a portfolio analysis of Illinois grain farms*. North Central Journal of Agricultural Economics, Vol. 9, 77-84.

Appendix

Relationship between the correlation coefficient between asset returns and portfolio variance: Case of n-assets

The variance of the rate of return of an equally weighted portfolio of n-assets, $V(p)$ is

$$(A1) \quad V(p) = \sum_{i=1}^n \frac{1}{n^2} \text{Var}(x_i) + \sum_{i=1}^n \sum_{j=1, j \neq i}^n \frac{1}{n^2} \text{Cov}(x_i, x_j)$$

where $\text{Var}(x_i)$ is the variance of the asset i's rate of return, and $\text{Cov}(x_i, x_j)$ is the covariance of the rates of return of assets i and j. $\text{Cov}(x_i, x_j)$ can also be written as

$$(A2) \quad \text{Cov}(x_i, x_j) = \Psi_{ij} \sigma_i \sigma_j$$

where Ψ_{ij} is the correlation coefficient between the rates of return of assets i and j, and σ_i , and σ_j

are the respective standard deviations of the rates of return of assets i and j.

The derivative of $V(p)$ with respect to Ψ_{ij} is

$$(A3) \quad \begin{aligned} \partial V(p) / \partial \Psi_{ij} &= 2 n^{-2} \sigma_i \sigma_j > 0 && \text{for } \Psi_{ij} > 0 \\ &= 0 && \text{for } \Psi_{ij} = 0 \\ &< 0 && \text{for } \Psi_{ij} < 0 \end{aligned}$$

From above, *ceteris paribus*, given that $\Psi_{ij} > 0$ a decrease in Ψ_{ij} results in a decrease in portfolio variance $V(p)$; if $\Psi_{ij} < 0$, a decrease in Ψ_{ij} (i.e., becomes more negative), also decreases the portfolio variance. Thus as the correlation between two rates of return varies from +1 to -1, the variance of the portfolio rate of return decreases.